International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 8, Issue 2, Apr 2018, 557-566

REVIEW ON ELECTRIC VEHICLES

SUMATHY MUNIAMUTHU, KRISHNA ARJUN. S, JALAPATHY. M, HARIKRISHNAN. S, VIGNESH. A

[1]*Associate Professor, Department of Mechanical Engineering, Vel tech, Avadi, Chennai, Tamilnadu, India*

[2,3,4,5]*Student, B.E. Final year, Department of Mechanical Engineering, Vel tech, Avadi, Chennai, Tamilnadu, India*

ABSTRACT:

The world wide determination to switch from pollution causing conventional automobiles that run on fossil fuels, to electric vehicles which are pollution free that function with electric power supply drawn from renewable resources, is eventually increasing. This review work aims at the study of journals, blogs and statistical reports to bring forth the evolution of electric hybrids, their sources of supply, pros and cons, their classification and major constituents. The major drawbacks of electric vehicles are analyzed and solutions are rendered. Characteristics of Torque development, CO_2 emission and factors affecting the deployment of electric vehicles are also briefed. Load performance, range characteristics, heat management, anti-jerking mechanisms, wireless charging and several other studies regarded to e-vehicles are included. The rising demand for e-vehicles, their sales and their substantial increase in numbers, government policies to promote the usage are also brought into the limelight. India's promising e-vehicle plan for 2030 and the steps taken to popularize electromobility are also reviewed. The journal summarizes that the renewable way of producing green electricity and concepts of electromobility will lead to a pollution free environment in the distant future.

***KEYWORDS:** Pollution, Electric Vehicles, Drawbacks, Demand, Government Policies, Green Electricity & Electromobility*

Received: Feb 03, 2018; **Accepted**: Feb 24, 2018; **Published:** Mar 08, 2018; **Paper Id:** IJMPERDAPR201865

Original Article

INTRODUCTION

Fossil fuels are the most commonly and widely used fuels all over the world. And in the very short period of time since then – just over 200 years –humans have consumed an incredible amount of them, leaving fossil fuels all but gone and the climate seriously impacted. The fuel reserves are finite and the rate at which the world is consuming fossil fuels is not standing still. Fossil fuels will therefore run out earlier. Globally, the consumption of oil points to the equivalent of over 11 billion tonnes every year. Crude oil reserves are vanishing at the rate of 4 billion tons a year. If this gets carried on at this rate, without any increase for our growing population or aspirations, our known oil deposits will last until 2052[1]. People need to switch to green energy and boycott energy companies that don't offer it. Switching to green energy is the single biggest thing we can do to fight climate. Green energy can be sourced from all the renewable sources such as wind, the sun, tides, and the earth and so on. Production of electricity and efficient usage determines the credibility of the future growth of industrial sector, transportation and survival. With leading levels of pollution and environmental damage, the introduction of new and hazard free form of energy deliberately becoming vital. The age of the fossil fuel engines are vanishing gradually and development of innovative technologies has started to revolutionize the world.

ELECTRIC VS HYBRID VEHICLES

A vehicle is a hybrid, if it utilizes more than one form of onboard energy to achieve propulsion. A hybrid will have a traditional internal combustion engine and a fuel tank, as well as one or more electric motors and battery pack. Hybrid systems and diesel engines, both represent extra cost. So far, installing both in the same vehicle has proven to be prohibitively expensive. The motor coupled with generator is to generate electricity to recharge the battery as it absorbs a portion of the vehicle's momentum when slowing or coasting downhill. Normal cars waste all of their excess momentum as heat in the brakes. Regenerative braking is insufficient to stop a car quickly, so conventional hydraulic brakes are still necessary. Operating the vehicle on electric power alone is possible if the hybrid system has enough electrical capacity. Plug-in hybrids began appearing in the market at the end of 2010. It provides a way to plug the battery into an electrical outlet for recharging while parked. The benefit of the plug-in hybrid is its ability to travel in all-electric mode for most short trips, reserving the gasoline engine for longer drives.

Classification of Hybrid and Electric Drive Vehicles

- Micro Hybrid Gasoline/Diesel driven engines where electric components are used in start stop functions alone.
- Mild Hybrid engines in which the electric motor supports the combustion engines using regenerative braking.
- Full Hybrid engines in which the electric motor supports the combustion process. It is possible to drive exclusively using electricity alone.
- Emission-free vehicles that do not release exhaust gases into the environment during operation are also called “zero-emission vehicles”.
- Battery-powered vehicles that are moved exclusively by an electric drive are also called “battery electric vehicles” (BEV). The energy required to run the vehicle is supplied by a high-voltage battery that is charged externally.
- Plug-in-hybrids have high voltage batteries that can be charged externally.
- Hybrids with Range Extenders have combustion engines that produce electrical energy to run the electric motor.
- Electric vehicles with fuel cells in which the energy for operation is produced by a fuel cell. It is fuelled with hydrogen.

The Main Components of an Electric Vehicle

The electric vehicle drive system includes:

- High-voltage battery with control unit for battery regulation and charger.
- Electric motor/generator with electronic control and cooling system.
- Transmission including the differential.
- Brake system.
- High-voltage air conditioning for vehicle interior climate control.

The various components are listed below.

Electric motor/generator, Transmission with differential, Power electronics, High-voltage

Lines, High-voltage batteries, Electronics box with control unit for battery regulation, Cooling system, Brake systems, High-voltage air conditioner compressors, High-voltage heating, Battery chargers, charging contact for external charging, External charging sources.

Fuel Cell Vehicles

Fuel cell vehicles (FCVs) have the potential to significantly reduce our dependence on foreign oil and lower harmful emissions that contribute to climate change. FCVs run on hydrogen gas rather than gasoline and emit no harmful tailpipe emissions. The Fuel cell has the following constituents. The Power control unit governs the flow of electricity. The Electric motor propels the vehicle more quietly, smoothly, and efficiently than an internal combustion engine and requires less maintenance. The Fuel Cell Stack converts hydrogen gas and oxygen into electricity to power the electric motor. The High-Output Battery stores energy generated from regenerative braking and provides supplemental power to the electric motor. The Hydrogen Storage Tank stores hydrogen gas compressed at extremely high pressure to increase driving range. FCVs look like conventional vehicles, but use cutting edge technologies. The heart of the FCV is the Fuel Cell Stack. The stack converts hydrogen gas stored onboard with oxygen from the air into electricity, which powers the vehicle's electric motor.

Solar Powered Electric Vehicles

Solar cars harness energy from the sun by converting it into electricity. This electricity fuels the battery that runs the car's motor. Instead of using a battery, some solar cars direct the power straight to an electric motor. Great examples of the latest solar powered cars are the University of Michigan Car, the MIT Solar car, and the Berkley Solar car. Photovoltaic cells are the components in solar panels that convert the sun's energy to electricity. They're made up of semiconductors, usually silicon that absorbs the light. The sun's energy frees electrons in the semiconductors, creating a flow of electrons. That flow generates electricity that powers the battery and the specialized motor in solar cars. Their solar panel work silently so they don't add to the noise pollution already on the road. Solar panels don't create greenhouse gases, as gasoline engines do. Most importantly, solar energy is free, widely available, and grants the solar car driver complete independence from foreign oil. Solar cars combine technology found in the aerospace, bicycle, alternative energy and automotive industries.

PROS OF ELECTRIC VEHICLES

When compared to gasoline engines, the price of fuel is almost eliminated and the recent advancements help in the easy charging of electric vehicles. Currently, the fastest method of charging electric vehicles is known as DC fast charging. EV owners can also pair home charging stations with solar panels, achieving true zero-carbon driving. But even without a home charging station, it's becoming easier than ever to charge an EV at a public station. Noise pollution is detrimental to human health, and the engines of gasoline- and diesel-powered vehicles are among its most significant sources. Electric vehicles, on the other hand, are almost whisper-quiet. That's because electric vehicles offer superior power-to-weight-ratios compared to traditional cars. Furthermore, electric motors provide constant torque over time and a greater amount of available power. It's virtually impossible for a battery-powered car to explode on impact, and because heavy battery packs significantly lower an EV's centre of mass, the car is less likely to rollover. Electric vehicles come with fewer maintenance requirements, and therefore the maintenance costs are lower as well.

It’s important to note, however the heavier vehicles are often accompanied by higher levels of non-exhaust emissions, but those are going to decrease as the technology improves.

Torque Development Comparison

The electric drive motor will reach its maximum torque as early as the first revolution. It does not need a start-up phase to reach idling speed. Once a specific rpm figure has reached, the available torque falls as the revolutions increase. This motor speed is approximately 14,000 rpm. These characteristics of an electric drive motor mean that a complex transmission is not required. The internal-combustion engine requires an idling speed to produce a torque. The available torque increases as the engine speed increases. In addition, this characteristic of the internal-combustion engine requires a transmission with several gear ratios. The torque is transferred to the transmission via clutch or torque converter.

Co_2 Emissions

Before 2050, global warming should not exceed the value of 3.6° F (2°C) related to the earth's temperature from pre-industrial times. This goal can only be achieved by reducing CO_2 emissions. The plan is to reduce the CO_2 emissions per capita from the current 45 tons per year to 0.7 tons per year by 2050. Electric vehicles do not directly produce CO_2emissions. However, the analysis of CO_2 producers does not just evaluate the vehicle, but also the emissions that occur during the production of the electrical energy (e.g. in coal power stations).

In Germany in particular, electromobility is closely linked to the use of “clean electricity” (i.e. from renewable energy). It can be assumed that today's electricity mixture causes lower CO_2emissions per vehicle compared with vehicles with internal-combustion engines[2].

MAJOR DRAWBACKS OF ELECTRIC VEHICLES

The main disadvantages of electric car ownership concern range anxiety. It is the drawback that when the vehicle stops and there is no charging station nearby. The introduction of electric vehicles should not only aim at their popularity as a global concern, but should also point at the development of charging stations compulsorily. Another big disadvantage is that many drivers will have to install a charging station at home. Overall battery life is expected to be around a decade, and replacement battery packs can be costly. Finally, EV ownership doesn't eliminate fuel costs entirely. Generation of electricity also requires capital costs. All other car accessories viz. radio, car air conditioners, etc. use up electric power from batteries, which could drain quickly. The batteries that power these cars are a costly affair. While themselves being clean, there are toxic elements within batteries and which could spew toxic fumes. Batteries are what make these vehicles heavy. This is a disadvantage because weight puts pressure on batteries and they drain out faster.

Factors Affecting the Deployment of Electric Vehicles

Taeseok Yong et al[3]., proposed that there are several chronological factors affecting the deployment of electric vehicles. **Technology factors** are closely related to the characteristics of the EV, such as driving distance, charging time, EV purchase prices. Limited driving range, long charging time and EV’s high purchase prices are the obstacles to EV adoption and diffusion. Moreover, Electric vehicles take longer to charge than internal combustion engine vehicles. In addition, other technology factors, such as battery life, trunk space, top speed, are regarded as one of the technical barriers for limiting consumer adoption. Therefore, the **government's active policy support** is a major factor for the initial market creation and full-scale diffusion of EVs. Thus, many countries that promote electric vehicles are providing policy support such as purchase subsidies, public expenditure, tax reduction, tax exemption, EV deployment target, free charging, and

parking permissions. **Environmental factors** mean those that will affect EV adoption indirectly, but are out of the direct control of EV manufacturers. We can consider environmental factors as fuel prices, consumer characteristics, availability of charging stations etc.

Parameters Influencing Electric Vehicle Range

Range is considered as a key parameter of electric vehicles. The increasing electric vehicles range is important for acceptance of electro mobility. **Martin Mruzek et al[4]**., and their simulation results propose that the vehicle weight and size of the battery pack have the main impact on the range. Vehicle weight increases directly with battery capacity. Significant impact on the range has also driving style. It is better to use coasting when the traffic it enables instead of using recuperation braking. Using *coasting* is still more efficient than recuperation braking even if the energy from braking would be completely re-usable for driving. During acceleration, it is more important that the fact how long the motor operates in the area with high efficiency. The rightly designed electric motor size influences its usage in the area with highest efficiency. The result from the comparison of vehicles operating in urban traffic where the speed rarely exceeds 50 km/h is that the aerodynamic drag coefficient is not a major impact to the range.

Proposed Solutions, Studies and Other Drawbacks

Various other drawbacks faced are taken into study and several solutions are delivered by worldwide research departments and authors thereby proposing a suitable breakthrough.

Heavy Load Performance Characteristics and Issues

A Load Adaptive Control Approach for a Zero-Voltage-Switching DC/DC Converter Used for Electric Vehicles as proposed by **IEEE Transactions on Industrial electronics [5]**. It presents a load adaptive control approach to optimally control the amount of reactive current required to guarantee *zero-voltage switching* (ZVS) of the converter switches. The proposed DC converter is used as a battery charger for an electric vehicle (EV). Since this application demands a wide range of load variations, the converter should be able to sustain ZVS from full-load to no-load condition. The converter employs an asymmetric auxiliary circuit to provide the reactive current for the full-bridge semiconductor switches, which guarantees ZVS at turn-on times. The proposed control scheme is able to determine the optimum value of the reactive current injected by the auxiliary circuit in order to minimize extra conduction losses in the power MOSFETs.

Real World Driving Energy Consumption and Losses

Xinmei et al[6]., recorded the real world driving energy consumptions of electric vehicles by performing various tests. The energy from the grid suffers various losses such as charging losses, battery losses, motor losses, driveline losses, brake losses and load losses. A **physical-based statistical method** for evaluating the energy consumption of an EV is proposed. Using the relationship between the driving cycle and vehicle parameters, a simple binary linear function is derived, and a method to decouple the independent energy consumption characteristics of EVs is derived by **regression analysis**. The results show that the proposed method is able to represent the key energy consumption characteristics.

Impact of Electric Vehicle Charging Mode on Load Characteristics

J.Wang et al [7]., proposed that the large scale development of electric vehicle will have both benefits and potential stresses on the power grid. It is shown that uncoordinated charging of EVs' on the grid will produce a series of problems, while intelligent charging can improve the operation of the power grid. Based on several scenarios of charging

modes, such as plug and charge, night charging and intelligent charging, the corresponding EV load models have been established. Therefore, an analysis is performed for the load characteristics of power grid to demonstrate the impacts of different EV charging scenarios. The results demonstrate that **rational utilization of EVs' load and energy storage property** can help to decrease the maximum load of grid and the peak-valley difference, to stable load, and to raise the utilization of the power facilities.

Pilot Line and High Voltage Safety

The pilot line is a completely independent safety system that determines if all high-voltage components are correctly connected to the high-voltage system. The pilot line is a low-voltage system. The pilot line circuit is interrupted as soon as a high voltage contact on a high-voltage component is disconnected. This happens whenever a cable is disconnected, the maintenance connector is removed or when a high-voltage component is replaced. As soon as the high voltage system detects that the pilot line is interrupted at any point, the protective relays are opened and the high-voltage battery is isolated from the high voltage system.

Maintenance and Crash Safety

The high-voltage system normally has a **maintenance connector** near to the high-voltage battery as an additional safety feature for de-energizing the high-voltage system. If the maintenance connector is unlocked and removed, the pilot line is disconnected. This opens the contactors, causing the high voltage battery to be disconnected from the high-voltage system. It also separates the two halves of the battery. The maintenance connector may also contain the main fuse for the high voltage battery.

Deactivation of the high-voltage system and the de-energization of the high-voltage system are important for occupant protection in accidents, the safety of rescue personnel and safety of accident vehicles that has been brought in for repair. As a result, the high-voltage safety is linked to the **crash detection system** [2] via the airbag control module.

Wireless Charging of Electrical Vehicles

J Andersson et al [8]., concluded that the usability of **inductive charging** technology can have a high impact on perceived attractiveness, and should therefore be of focus in future developments of the technology. The study indicates that the charging behaviour will most likely be different with inductive charging. The clear benefit is no substantial evidence that perceived safety should hinder a wider adoption of inductive charging.

Energy Usage Assist Device

Martin Mruzek et al[4]., proposed electric vehicle energy usage assists for increasing vehicle range, system implementation and measured data for energy usage assist function. The system informs the driver about the limitations for example, caused by weather conditions or low battery state of charge. The role of the intelligent Energy Usage Assist is audiovisual communication with the driver. The **Energy usage assistance** will be receiving data from the vehicle control unit and the battery management system. Integrated GPS receiver will be used for detecting speed limits. Based on powertrain measured efficiency, maps system will inform driver through display how to behave.

Inter-Service Provider Charging Protocol (Ispcp): A Solution to Address Range Anxiety of Electric Vehicle Owners

Range anxiety describes the drivers' stress regarding the available battery range while driving an electric vehicle.

Khalil Salah et al[9]., highlighted that beside availability of charging stations, users need to have access to them. The availability of charging facilities is not enough to address range anxiety issue. Applying a communication protocol on new and existing networks will provide cross-network charging facilities to users by only subscribing to one network. Since during the trip, users do not need to worry about whether they can use a charging station on their destination or not, their range anxiety will be relieved. ISPCP is an interface protocol to standardize the communication among SP.

Active Anti-Jerking Control of Shifting for Electric Vehicle Driveline

Cheng Lin et al[10]., proposed a dynamic model of electric vehicle based on the Newton's second law, and an optimal anti-jerking shifting controller, which is for interrupting power input when shifting without a clutch in the powertrain, and a motor with quick response to an instruction signal to make it possible. The principle of optimal anti-jerking shifting control is based on the powertrain motion state, to output torque of motor in accordance with the control law, and by minimizing the cost function power is damped to zero before the gears detach in the transmission.

INCREASING DEMAND AND SALES

The electric vehicle market continues to expand, with more than two million electric vehicles sold worldwide by early 2017. Automakers continue to make commitments to shift their production to electric drive, and national governments have made ambitious plans to phase out internal combustion vehicles to meet their climate and air quality commitments.

The EV market in India is at a nascent but the promising stage.

- India's technology requirements for electric vehicles are different from that of the West due to the unique environmental condition and driving pattern. Hence, investments to make electric vehicle technology affordable are immense.
- Realization requires a consistent government policy. Bosch has plans to move into first series production in the Indian market in 2018. Beyond focus on Battery Electric Vehicle, India should not lose the benefit that hybrid vehicles can bring to a car owner and the environment.
- The ideal powertrain of the future will be a mix of electromobility and internal combustion engines combined with renewable electric power for optimum value delivery.
- In order to resolve the issue of charging stations and lack of charging infrastructure in the country, public private partnerships need to be explored.
- The fuel efficiency norms coming up in the next five years would warrant, high end technologies that include hybrids to be able to meet the target legislations, says **Jan-Oliver Rohrl**, Chief Technology Officer and Additional Director, Bosch [11].

The world’s best-selling battery electric and plug-in hybrid vehicles include Tesla's Model S, Nissan’s Leaf and Toyota’s Prius Plug-in Hybrid. Tesla and Panasonic paved the way for the construction and operation of the world's largest battery factory in the United States. In the first quarter of 2017, Tesla delivered about 25,000 vehicles worldwide. China is ranked as the largest market for all-electric vehicles.

India's E-Vehicle Plan

The Indian government recently became proactive in making India a nation of electric cars.

- In January 2017, the Indian government announced to bear up to 60% of the research and development (R&D) cost for developing the indigenous low-cost electric technology.
- The government is inking a deal with SoftBank for a low-interest funding of around 2 Lakh electric buses to be deployed in public transport.
- **A fleet of 200 electric-powered public transport vehicles** would be run on Ola's app platform in Nagpur. While Mahindra Motors would supply 100 e2O Plus electric vehicles, the remaining 100 vehicles are being deployed by Tata Motors, Kinetic, US electric vehicle maker Build Your Dreams (BYD), and TVS, among others.
- According to the Society of Manufacturers of Electric Vehicles, there has been a 37.5% rise in the sale of EVs in India; electric cars constitute only 9.09% of the figure.
- Delhi, Mumbai, Pune and many others top the list of the world's most polluted cities. While at one end some world leaders fail to recognize climate change as a real problem, **India's step to sell only Electric Cars by 2030 will prove to be a boon for the environment.**

CONCLUSIONS

The journey of electric vehicles right from evolution to present day's implementation has deeply undergone several hindrances and conundrum. The global concern to curb the hazardous effects of vehicle exhaust and climatic intolerance has transitioned minds of countries to face towards the change from the conventional oil run automobiles. The shortage and soaring costs of oil, universally, has finally set up a stage for many nations to devise plans for e-vehicle usage. Many on-road conditions and scenarios concerned with e-vehicles are studied and several technical and theoretical remedies have been continuously posted front. The journal study concludes with a positive note that the renewable way of producing green electricity and concepts of electromobility will lead to a pollution free environment in the distant future.

REFERENCES

1. *All fossil fuel reserve and consumption data from CIA World Factbook.*
2. *www.natef.org*
3. *Taeseok Yong, Chankook Park: A qualitative comparative analysis on factors affecting the deployment of electric vehicles (Energy Procedia(ELSEVIER), Volume 128, September 2017, Pages 497-503)*
4. *Martin Mruzek*, Igor Gajdáč, ĽubošKučera, DaliborBarta: Analysis of Parameters Influencing Electric Vehicle Range (Procedia Engineering, Volume 134, 2016, Pages 165-174)*
5. *(Volume: 59, Issue: 2, Feb. 2012)*
6. *Xinmei Yuan, Chuanpu Zhang, Guokai Hong, Xueqi Huang, Lili Li: Method for evaluating the real-world driving energy consumptions of electric vehicles (Energy(ELSEVIER), Volume 141, 15 December 2017, Pages 1955-1968)*
7. *J. Wang et al.,: Impact of Electric Vehicle Charging Mode on Load Characteristic in the Shandong Electric Power Grid, (Advanced Materials Research, Vols. 608-609, pp. 1582-1586, 2013)*

8. *Jonas Andersson, Maria Nilsson,Stefan Pettersson: Introducing Wireless Charging for Drivers of Electrical Vehicles in Sweden—Effects on Charging Behaviour and Attitudes.*
   (Advances in Human Aspects of Transportation pp 951-962)
9. *Khalil Salah, Nazri Kama: Inter-service provider charging protocol: a solution to address range anxiety of electric vehicle owners (Energy Procedia Volume 136, October 2017, Pages 157-162)*
10. *Cheng Lin, Shengxiong Sun, Wenfei Jiang: Active anti-jerking control of shifting for electric vehicle driveline (Energy Procedia, Volume 104, December 2016, Pages 348-353)*
11. *www.theicct.org*